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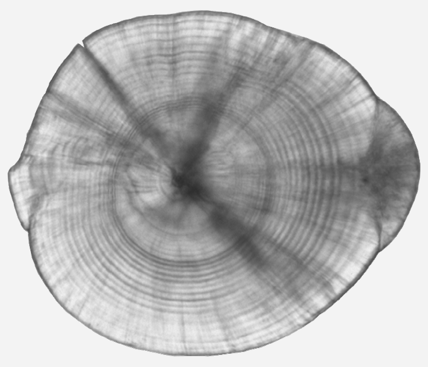

Connectivity, growth and survival in a spatially structured fish population, which is currently managed as seven separate stock units

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Introduction

> Predicting stock recruitment for short lived industrial species can be challenging as they normally enter the fished stock early in life, thereby limiting the chance to collect biological data before hand.

> Nevertheless, predictions of stock recruitment in the industrial fiseries are of major importance since significant proportions of the catches are made up of newly recruited fish.

> It is generally acknowledged that **growth affects the survival of early life stages**. For instance, growth determines predation risk and **overwinter survival**.

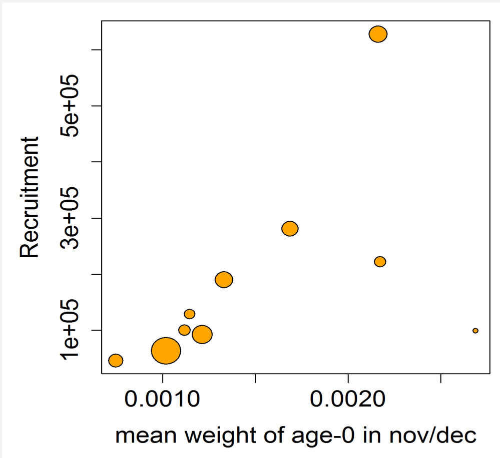
> However, in **spatially structured fish stocks** (resident behaviour and habitat attachment), **hydrographic dynamic forcing** may complicate things considerably, as it affects retention and advection processes and influences the growth conditions experienced by the drifting larvae.

Pressent study

> In the present study we have focused on the short lived lesser sandeel (*Ammodytes marinus*) population in the North Sea .This stock is spatially structured (currently managed as a cluster of sub stocks) with strong affinity to distinct habitats distributed patchily in the North Sea.

> On the Dogger Bank in the North Sea, weights measured during a juvenile-survey and recruiment estimates from stock assessment models indicate that growth and recruitment success are interlinked (SEE GRAPH TO THE RIGHT).

> We investigated **[A]** spatial variation in hydrodynamically influenced drift patterns of sandeel larvae, **[B]** the role of hatch date on growth, and **[C]** possible linkages between growth in early live and the probability of surviving the first winter.



Interlink between recruitment and juvenile growth. (Bubble size indicate spawning stock biomass)

Methods

Location and samples

- Larval samples: 1) Dogger Bank, 2) Central banks, 3) North Eastern banks. Year-classes 2006, 2008, 2009
- Otoliths: Pre and post winter 0- and 1-group sandeel from Doggerbank, year-classes 2008 and 2009

Larval drift

- Age estimates of larvae from otolith daily increments analysis . Age assumed to represent drift duration.
- Backtracking larvae in a hydrographical drift model of the North Sea to estimate and map most possible hatch origin

Growth

- Growth proxy derived from increase in otolith daily increment width
- Hatch date: Catch date minus larval age
- Larval somatic growth proxy: Residuals of larval size—otolith size relationship

Overwintering survival

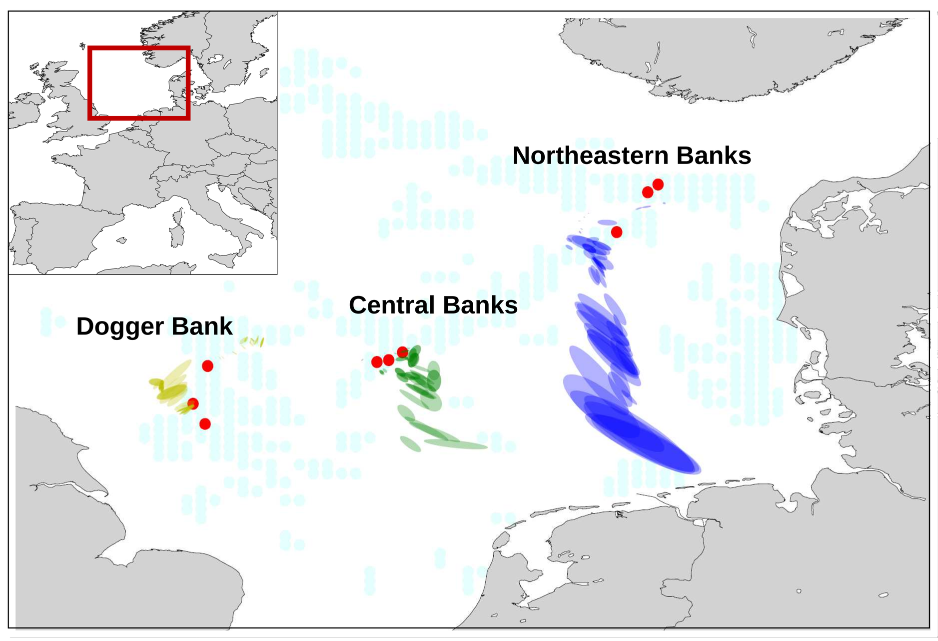
- Comparison of otolith growth rates from daily increments of pre– and post winter samples

Results

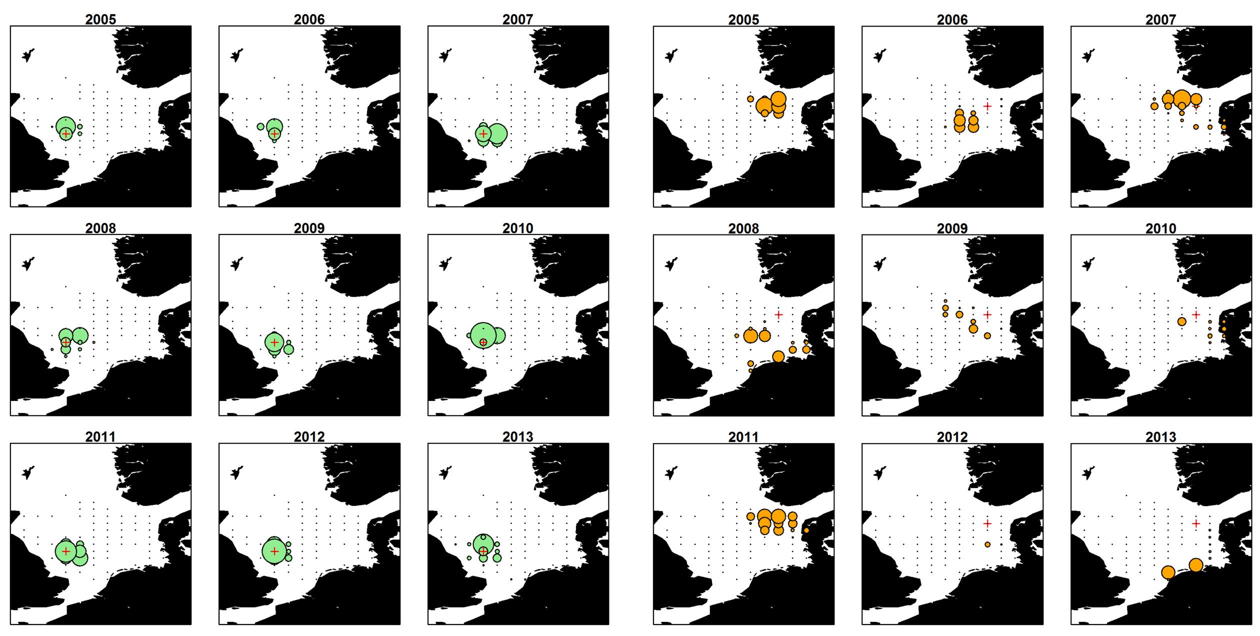
[A] Spatial variation in larval drift

Objective: To investigate spatial variation in drift patterns

- Drift patterns are dynamic between areas and years
- Dogger Bank is a self-supplying area with a high degree of retention in all study years
- Central and North-eastern Banks show higher connectivity with spawning grounds further south and are to a higher degree susceptible to changes in drift patterns
- Interannual variability in drift distance and direction is increasing from Dogger Bank to North-easter banks



Modelled drift patterns of larvae in 2008. Dogger Bank is self supplied, while recruitment to the central and North-eastern areas drift from southern and possibly coastal areas. (Ellipse areas cover approximately 70% of possible hatch sites. Red dots: sample positions. Blue shaded areas: sandeel habitat)

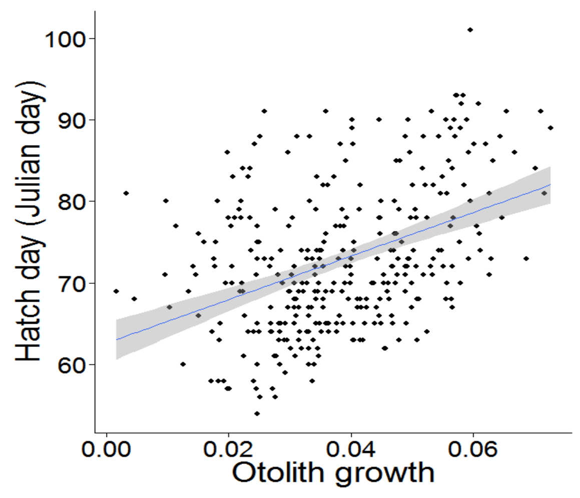


Yearly model predictions of the origin (hatch area) of larvae settling at two sites in the North Sea (Dogger Bank (left map) and North Eastern North Sea (right map). The sites are indicated with "+" on the maps. Bubble size indicate contribution from a given location relative to other locations. The prediction assume homogenous distribution of spawning biomass across suitable sandeel habitat and spatially invariable larval mortality

[B] Larval growth and hatch date

Objective: To test whether otolith growth rate is a proxy for larval somatic growth or for hatch date

- Otolith growth showed a significant correlation with somatic growth rate proxy (residuals of the larval size—otolith size relationship), but explaining only 3% of the variance (p= 0.003, r^2=0.03) (Not shown).
- Otolith growth was significantly correlated with hatch date, with late hatching larvae showing faster increase in daily increment widths, indicating faster growth (p< 0.001 , r^2= 0.18) (Graph below).

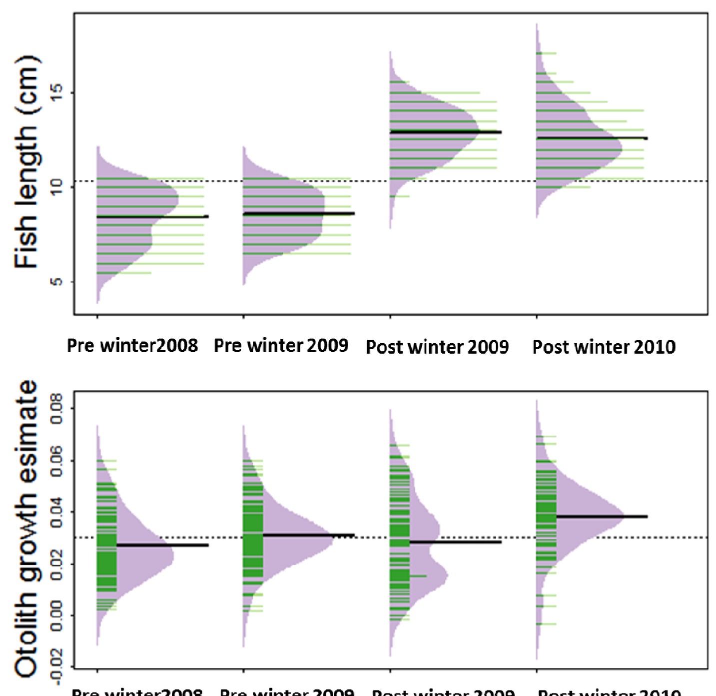


Hatch date in relation to otolith growth

[C] Overwinter survival and growth

Objective: To test whether individuals with faster otolith growth rates have higher over-winter survival on Dogger Bank

- Considerable somatic growth (ca. 4cm) occurred during the period from before to after winter
- Linear mixed effects model comparison and estimation of otolith growth, showed significant higher mean increments for survivors of the winter 2009/2010 caught at the commence of fishery April/Mai compared to juveniles caught before winter in Nov/Dec. No such difference was found for the winter 2008/2009.



Lenght distributions before and after the winters of 2008 and 2009 (upper panel) with corresponding otolith growth (lower panel). (Dottet line: overall mean. Black lines, sample means)

Conclusions

[A] Results indicate that Dogger Bank is a self-contained reproductive system while central and northern sandeel habitats received more recruitment from more distant regions, suggesting a source-sink approach to the stock may be appropriate. Improved understanding of link between inter-annual variation in hydrodynamics and stock recruitment may proof useful in future attempts to develop spatial explicit forecasts of the recruitment success of this stock.

[B] Larvae hatching late in the season appeared to be growing faster. This advocates for research dealing with the link between stock recruitment and inter-annual variation in timing of primary and secondary production in spring.

[C] There were some indications that growth in early life affected overwinter-survival. However, the results were inconsistent. Also the considerable difference between the size of juveniles in December (from scientific sandeel survey) and the size of age-1 sandeel caught in the fishery in April (overwintering lasts until late March—early April) indicates increased overwinter-mortality of the smallest individuals.

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